



Lesson 8:

Geology Conclusion: Summarizing Learning

Students review astronomy and atmosphere systems and draw connections to geological processes and structures. They then summarize their learning from this unit in a final project.



Main Lesson Concept: The Earth's structure is an important part of the Earth's system, which is composed of several layers. The movement of these layers affects the atmosphere and biosphere.



Scientific Question: How are the Earth's structure and processes important to the Earth system, especially as it supports habitability to humans?

Objectives		Standards
<ul style="list-style-type: none">Students will draw and explain concept maps that show how the Earth's interior characteristics and processes interact with many different systems to support human habitability.Students will write a guided tour for the Earth's structure and processes explaining how these processes contribute to a habitable planet for humans.		<p>Partially meets: 2061: 4C (6-8) #1</p> <p>Addresses: 2061 4B (6-8) #2 2061 11A (3-5) #1 2061 11A (3-5) #2 2061 11A (6-8) #2 2061 11A (6-8) #3 NSES D (5-8) #1.8</p>
Assessment	Abstract of Lesson	
Concept maps and guided tours.	Students review the characteristics of systems, the planetary temperature system, human body system, and the connections between the atmospheric and astronomical characteristics that support the human body system. They then draw concept maps that show the interaction of geologic structure and processes with important systems that support human survival. Finally, students write a guided tour of the Earth's interior and processes that describes the importance of each to help maintain the habitability of Earth.	
Prerequisite Concepts		
<ul style="list-style-type: none">Humans need water, oxygen, food, gravity, a moderate temperature, and protection from poisonous gases and high levels of radiation to survive. (Astronomy Lesson 1)Systems consist of many parts that usually influence each other. A system may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched or misconnected. Thinking about things as systems means looking for how every part relates to other parts. Any system is usually connected to other systems. (Astronomy Lesson 7)The type of star, the orbital distance of a planet and the mass of the planet are the major components of the planetary temperature system that determine the surface temperature of the planet. (Astronomy Lessons 9 and 11)A large object, such as a Jupiter-size planet, orbiting near an Earth-size planet, could disrupt the planetary temperature system. (Astronomy Lesson 12)Carbon dioxide and water vapor are greenhouse gases that absorb energy radiated from Earth's surface and reradiate some of it back towards the Earth, increasing the surface temperature. (Atmosphere Lesson 3)Oxygen is important to humans because it helps to generate energy in the cells from sugars. (Atmosphere Lesson 5)		





Geology Training Module	Temperature, Pressure, and the Earth	Density	Convection in the Earth	Plate Tectonics and Volcanism	Carbon Cycle and Life	Magnetic Field and Life	Geology Conclusion: Summarizing Learning
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Prerequisite Concepts (continued)

- The creation and destruction of ozone in the stratosphere protects life on Earth from harmful ultraviolet radiation. (Atmosphere Lesson 6)
- Nitrogen, like other substances, can have an effect on life because of its unique properties and because of the amount of it in the environment, which contributes to air pressure necessary for life functions. (Atmosphere Lesson 7)
- Humans need the following geologic conditions (Geology Lesson 1):
 - Liquid outer core (coupled with the planet's rotation and a thick atmosphere)
 - Viscous mantle (slow motion)
 - Slow motion of crust and upper mantle (lithosphere) of 3-5 cm/year
- Temperature and pressure are key factors that determine geologic conditions. (Geology Lesson 2)
- Density determines whether a substance will float on another substance and thus affects the composition of Earth's layers. (Geology Lesson 3)
- The interior of the Earth is hot. The heating and cooling of the mantle results in convection cells and movement inside the Earth. (Geology Lesson 4)
- The Earth's solid crust is composed of separate sections that constantly move on a partially molten layer of the upper mantle. Major geologic events such as volcanic eruptions result from these plate motions. (Geology Lesson 5)
- The movement of the crust and mantle allows carbon to be cycled in and out of the atmosphere, stabilizing the surface temperature. (Geology Lesson 6)
- The rotation of the Earth and its liquid outer core generate a magnetic field that, with the atmosphere, helps protect us from cosmic rays from exploding stars and harmful solar wind produced by our star, the Sun. (Geology Lesson 7)

Major Concepts

- The structure, composition, and mass of the Earth determine its structure and processes, all of which affect Earth's atmosphere and ability to support human survival.
- Like all systems, the Earth's structure is made up of parts that influence each other and can be part of other systems.
- The structure and composition of Earth's layers can affect the survival of humans.
- The amount of carbon dioxide in the atmosphere is an important factor in maintaining a moderate surface temperature.
- The amount of carbon dioxide in the atmosphere is determined by the carbon cycle, in which carbon is trapped in rocks and shells and then broken down and released through volcanoes and living processes.
- The slow movement of the crust and upper mantle results in volcanoes at plate boundaries. Movement in the mantle occurs as a result of convection. As mantle material increases in temperature, it becomes less dense and rises. When the temperature of the mantle material decreases, the density of the material increases and it sinks down.
- The lower part of Earth's upper mantle is partially molten. Earth's lithospheric plates float upon this layer.
- Earth's lower mantle is solid, but capable of flow due to the extreme pressures inside the Earth. The extreme pressure comes from the Earth's mass, which plays a role in making the inside of the Earth hot.
- The Earth's liquid outer core generates a magnetic field that, with the atmosphere, helps protect us from cosmic rays produced by exploding stars and harmful solar wind produced by our star, the Sun.



Suggested Timeline (45-minute periods):

- Day 1: Engage and Explore Sections
- Day 2: Explain and Extend Sections
- Day 3: Evaluate Section





Geology Training Module	Temperature, Pressure, and the Earth	Density	Convection in the Earth	Plate Tectonics and Volcanism	Carbon Cycle and Life	Magnetic Field and Life	Geology Conclusion: Summarizing Learning
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Materials and Equipment:

- A class set of System Concept Map and Final Geology Project
- Concept Map of the interaction of the atmospheric gases with the planetary system and human body system from Atmosphere Lesson 8 (optional)
- Chart paper for class concept maps, chart of the importance of Earth's structure to humans, and lesson main concept
- Construction paper or blank white paper for students to draw their concept maps
- Different colored pens or colored pencils (for student concept maps)
- Earth's Structure Transparency (optional)
- Computers with "PowerPoint," "Hyperstudio," "Kid Pix," or other multimedia software for Final Geology Project (optional)

Preparation:

- Prepare chart to record Earth's structure and its importance to humans.
- Gather materials.
- Duplicate System Concept Map and Final Geology Project.
- Prepare Earth's Structure Transparency (optional).
- Prepare chart paper with the major concept of the lesson to post at the end of the lesson.

Differentiation:

Accommodations

For students who may have special needs:

- Have them report orally to the teacher to explain their concept maps and guided tour or have them act out their guided tour with a partner.

Advanced Extensions

For students who have mastered this concept:

- Write a guided tour of another planet or moon in our solar system describing why the structure and processes do not meet human habitability requirements and what changes would need to take place to meet human habitability requirements. Be sure to include the astronomical and atmospheric changes that would also be required to make the planet or moon habitable to humans.



Engage

(approximately 25 minutes)

1. Review systems, the human body systems (Astronomy Lesson 7), and the planetary temperature system (Astronomy Lessons 9, 11, and 12).

- Question: What are the characteristics of a system?
- Answer: *Systems consist of many parts that usually influence each other. A system may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched, or misconnected. Thinking about things as systems means looking for how every part relates to other parts. Any system is usually connected to other systems.*
- Question: What system is largely based on the astronomical characteristics of our solar system?
- Answer: *The planetary temperature system.*

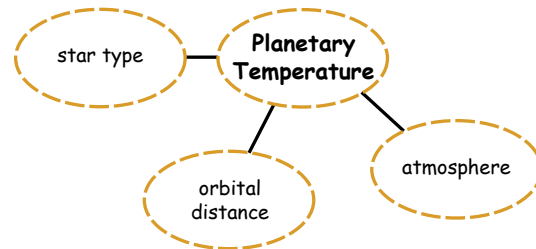




Geology Training Module	Temperature, Pressure, and the Earth	Density	Convection in the Earth	Plate Tectonics and Volcanism	Carbon Cycle and Life	Magnetic Field and Life	Geology Conclusion: Summarizing Learning
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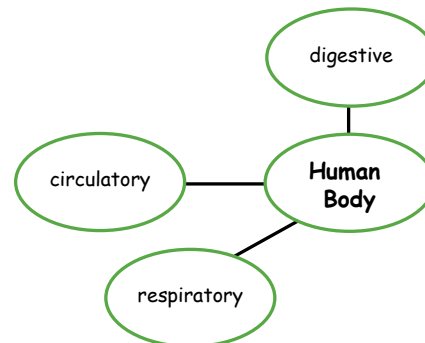
- Question: How is this system important to human survival?
- Answer: *The planetary temperature system is important to human survival because we need a moderate temperature that allows water to be a liquid and a temperature that is comfortable for our bodies to function.*

- Question: What are the parts of the planetary temperature system?
- Answer: *(As you discuss, begin to draw this as a concept map on the board.) The three main parts that determine the surface temperature of a planet are: star type, orbital distance, and atmosphere.*



Note to Teacher: If you have completed the concept map activity with the class in Atmosphere Lesson 8, simply review it at this time.

- Question: What are some of the important systems that make up the human body and help to keep us alive?
- Answer: *(As you discuss, begin to draw this as another concept map on the board.) Some of the systems that make up the human body are the respiratory system, the circulatory system, and the digestive system.*
- Question: What are these systems? How do they work? How do they relate to each other?
- Answer: *They have parts that usually relate to each other or work together. If one part is missing or broken, the whole system can be affected. For example, if the star type is very hot, the planet will need to orbit at a further distance in order to maintain a temperature that is habitable for humans.*



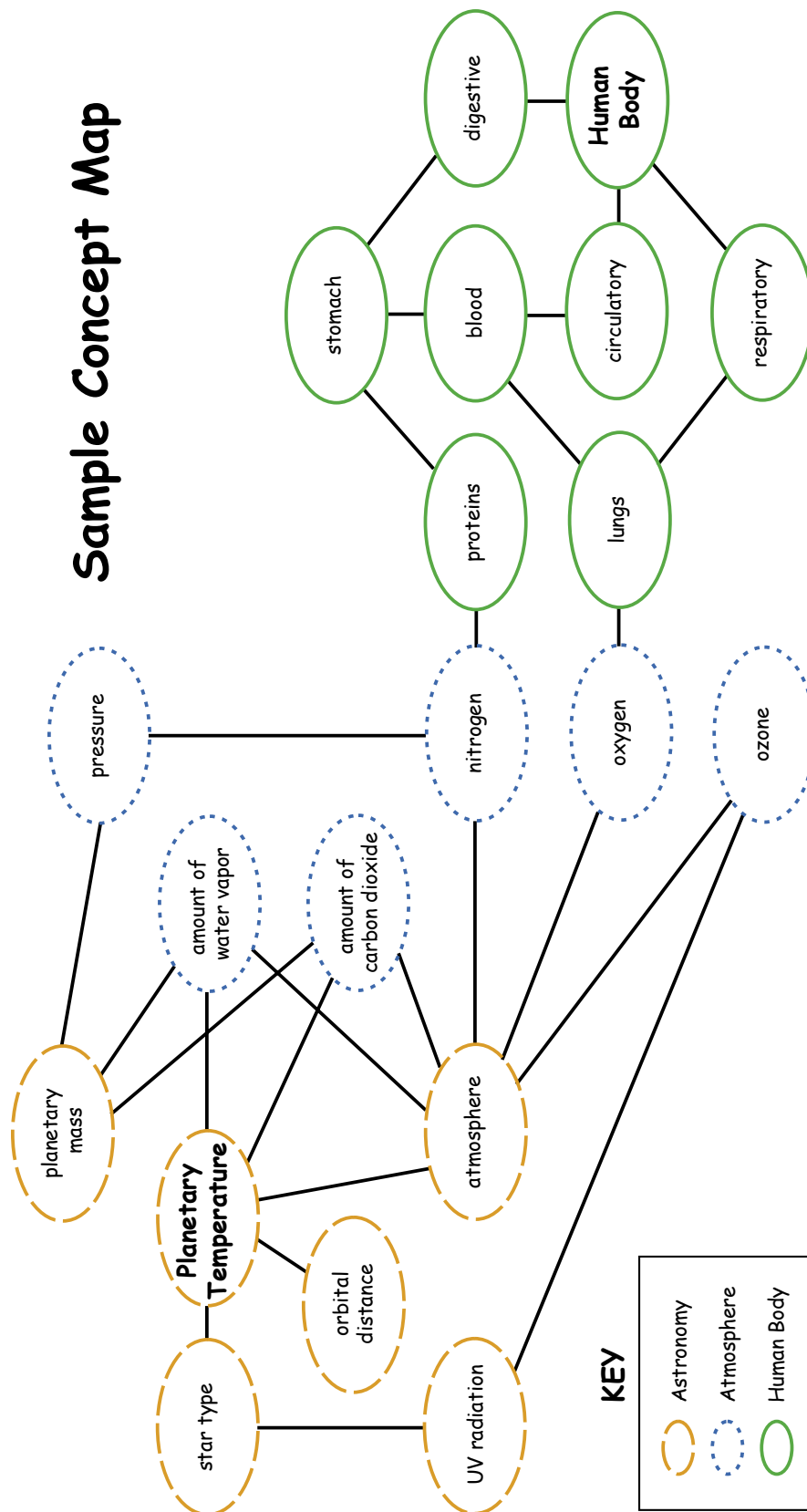
2. Review the interaction of the atmospheric gases with the planetary temperature system and human body system (Atmosphere Lesson 8).

- Question: How do the gases in our atmosphere interact with these two systems to support human habitability?
- Answer: *(Add to the concept map as students identify each of these. See the concept map on the next page as a guide to the types of connections to include.) Answers should include:*
 - *Carbon dioxide and water vapor are greenhouse gases that absorb radiation that bounces off Earth's surface and reradiate it back to Earth, playing an important role in the surface temperature of a planet. The amount of an atmosphere (including greenhouse gases) that a planet has is related to the force of gravity of that planet, which in turn depends on its mass.*
 - *The strength of gravity of a planet, along with its atmosphere, determines the surface pressure. We need the right amount of pressure to keep gases inside our body and to keep water a liquid on Earth's surface.*
 - *Nitrogen is an inert gas that makes up the bulk of our atmosphere contributing to the necessary pressure we need. Nitrogen is also a building block of proteins, which make up important parts of our bodies. Nitrogen is brought into our bodies through the digestive system.*
 - *Oxygen is highly reactive and reacts with sugars to give us energy. We breathe oxygen in through the respiratory system. It is circulated to the cells through the circulatory system, where it reacts with sugars that are brought in through the digestive system.*
 - *Ozone absorbs harmful ultraviolet radiation in the upper atmosphere and prevents much of it from reaching the Earth's surface where it can kill us. (You could connect ozone to the atmosphere part of the Planetary Temperature System. You could also connect ultraviolet radiation to the star type of the planetary temperature system, since most stars put out ultraviolet light.)*





Sample Concept Map





Geology Training Module	Temperature, Pressure, and the Earth	Density	Convection in the Earth	Plate Tectonics and Volcanism	Carbon Cycle and Life	Magnetic Field and Life	Geology Conclusion: Summarizing Learning
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3. Bridge to this lesson and introduce the purpose and Scientific Question.

- Say: Today, we are going to look at the Earth's structure and processes to see how they also connect to parts of the planetary temperature system and support the human body system. The scientific question we will explore is:
 - How are the Earth's structure and processes important to the Earth system, especially as it supports habitability to humans?

4. Review the Earth's structure and importance. (Geology lessons 2, 3, 4, 5, 6, and 7)

- Question: What are important characteristics and processes of the Earth's interior and how is each characteristic important to human survival?
- Answer: (You may want to record these on a chart as seen below.)

Note to Teacher: Students may not come up with all of the characteristics and processes listed below, or they may come up with different ones. This is okay. The important thing is to get them to talk about what the inside of the Earth is like and why this is important. It's also important to guide them to start to identify the connections between these characteristics and the important processes involved in cycling carbon in and out of the atmosphere and generating a magnetic field. The indented characteristics don't have a direct importance to humans, but play a role in determining the major Earth processes that affect human habitability. They are really sub-systems to the carbon cycle, so students may not list them here nor include them in their concept map. Again, this is fine. We include them in the discussion, so students will see how they are part of the larger systems.

Characteristic/ Process	Importance to humans
Volcanoes	Release carbon dioxide into the atmosphere, affecting the surface temperature
Trapping of carbon in rocks and shells	Take carbon out of the atmosphere, affecting the surface temperature
Slow mantle/crust movement	Volcanoes (that release carbon dioxide, affecting temperature) occur along plate boundaries that are moving toward each other or away from each other. The subduction of the plates is important in the process that cycles carbon in and out of our atmosphere.
Convection	The mantle moves in convection cells. Plate movement is related to the rate of mantle convection.
Density	Convection is driven by density of materials. As a substance becomes denser, it sinks. As it becomes less dense, it rises.
Internal heat/pressure	Internal heat and pressure affect the density of materials.
Liquid outer core	Generates a magnetic field that, with our atmosphere, helps protect us from solar wind and space radiation

- Say: In the next activity, we'll explore how these characteristics and processes interact with the planetary temperature system and human body systems to support human survival.





Geology Training Module	Temperature, Pressure, and the Earth	Density	Convection in the Earth	Plate Tectonics and Volcanism	Carbon Cycle and Life	Magnetic Field and Life	Geology Conclusion: Summarizing Learning
-------------------------	--------------------------------------	---------	-------------------------	-------------------------------	-----------------------	-------------------------	--



Explore

(approximately 20 minutes)

1. Have students draw concept maps and write explanations that show how the Earth's interior processes and characteristics interact with the atmospheric gases, planetary temperature system, and support human survival.
 - Go over the System Concept Map directions and rubric with students. Encourage students to look for ways to connect all parts to form one large concept map.
 - Students could start their concept maps in several different ways:
 - a. Students might branch off from "amount of carbon dioxide" and think about what factors determine the amount of carbon dioxide and the characteristics that drive these processes.
 - b. Students might begin from "pressure" and add characteristics of Earth's interior affected by pressure, eventually connecting to processes that affect the planetary temperature system.
 - c. Students may draw connections to "star type" and how characteristics of Earth's structure protect humans.
 - d. Some students may deviate from traditional concept maps by showing cycles or flows that have sequences. As long as students are showing connections, this is fine.
2. The following are some suggestions and questions that may help to guide the thinking of those students who are having trouble making connections.
 - Draw and explain the parts of the system that play a role in the Earth's planetary temperature system.
 - How is pressure important to Earth's interior processes?
 - What are the parts of the system that protect us from solar wind? How do the parts connect to the overall system?



Explain

(approximately 20 minutes)

1. Have students explain their concept maps, the connections they've made, and why to a partner.

Note to Teacher: Every student will have a different way of thinking about concepts, and concept maps can be powerful for seeing how students are making connections. They may not all be identical and some may reveal faulty logic. This is an opportunity to probe into how students are thinking about and connecting ideas and help them to correct any misunderstandings. The Sample Concept Map on page 154 is only one possible concept map.

2. The following types of questions may help students to see connections they may not have made or made erroneously.
 - Question: How do the Earth's structure and processes affect the amount of carbon dioxide in the atmosphere?
 - Answer: *Earth has volcanoes, which release carbon dioxide into the atmosphere. Carbon is removed from the air and reacts with rocks. Streams and rivers move the dissolved carbon into the ocean where it forms shells and limestone. Eventually, the carbon in the limestone is released as gas from volcanoes once again. These processes regulate the amount of carbon dioxide in the atmosphere.*





Geology Training Module	Temperature, Pressure, and the Earth	Density	Convection in the Earth	Plate Tectonics and Volcanism	Carbon Cycle and Life	Magnetic Field and Life	Geology Conclusion: Summarizing Learning
-------------------------	--------------------------------------	---------	-------------------------	-------------------------------	-----------------------	-------------------------	--

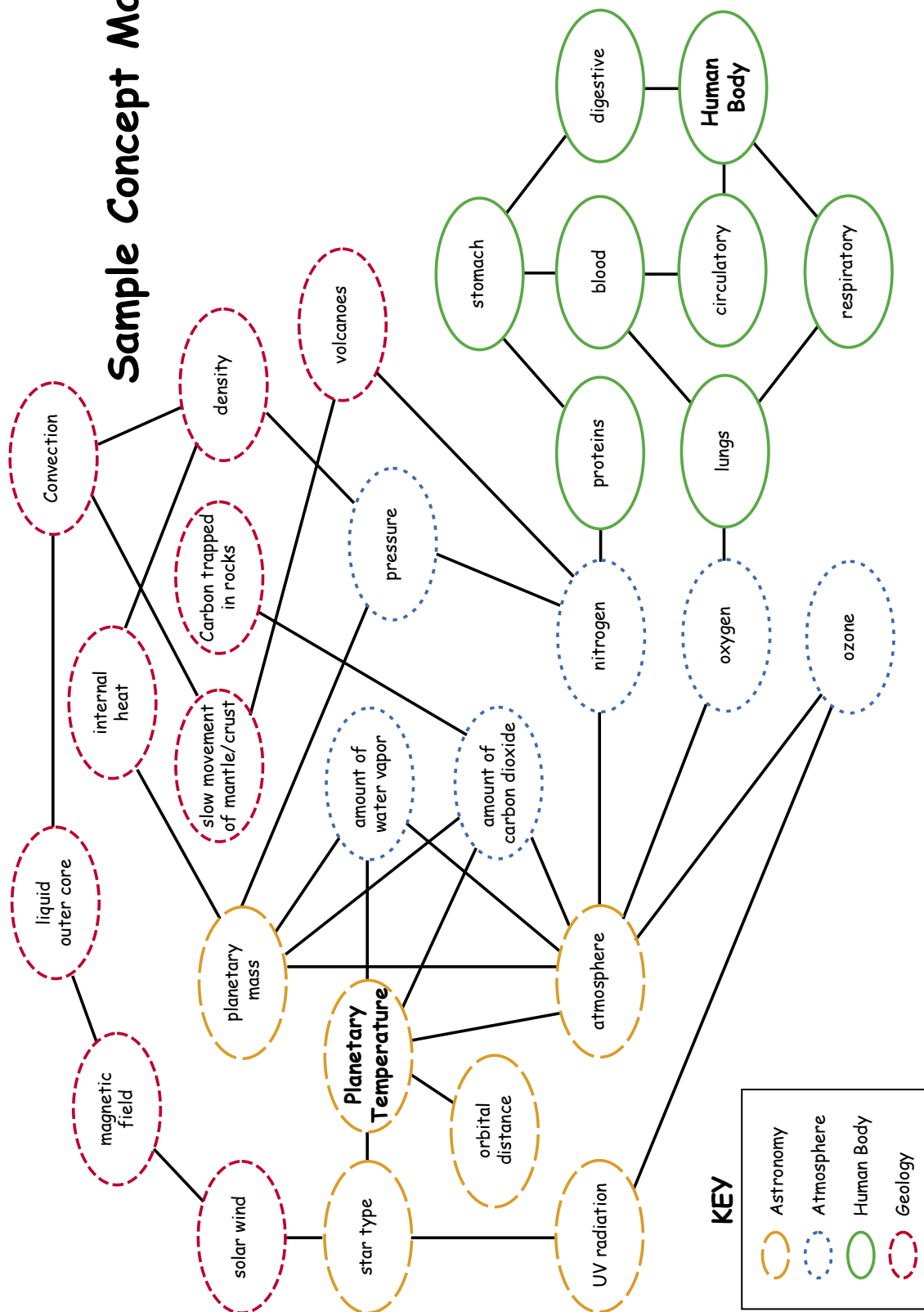
- Question: How does this carbon cycling influence the surface temperature of a planet? How is this important for life?
- Answer: *The cycling of carbon in and out of the atmosphere ensures that there is neither too much carbon dioxide nor too little. Carbon dioxide is a greenhouse gas that absorbs heat that radiates from the surface of a planet and reradiates some of it back to the planet's surface, raising its surface temperature. A moderate temperature that allows water to be a liquid at all times is essential for human survival. Greenhouse gases play an important role in determining whether a planet's surface temperature will be within an acceptable range for human survival.*
- Question: What characteristics of Earth's interior allow carbon to be cycled in and out of the atmosphere?
- Answer: *The slow movement of the crust and upper mantle results in volcanoes at plate boundaries. As the Earth's plates move, the limestone formed in the oceans is recycled back into the Earth, where volcanoes release it as a gas. Plate motion is affected by the movement of the mantle. Mantle movement occurs as a result of convection, when Earth's internal heat decreases the density of mantle material, which rises, cools, and becomes denser causing the material to sink down again.*
- Question: How are these geologic characteristics like sub-systems?
- Answer: *The carbon cycle is a system that includes volcanoes, plate movement, and mantle convection. The characteristics that play a role in causing volcanoes make up another system, which is a sub-system.*
- Question: What affects the states of matter of the Earth's interior?
- Answer: *Earth's mantle is viscous, allowing it to slowly flow and move. This is partly because of the pressure that comes from the Earth's mass, which plays a role in making the inside of the Earth hot.*
- Question: What role does the Earth's core play in supporting human survival, and how did you connect it to your system?
- Answer: *The Earth's liquid outer core generates a magnetic field that, with our atmosphere, helps to protect us from harmful solar wind and cosmic rays. You could connect liquid outer core to solar wind that in turn, could connect to star type, since our star produces the solar wind.*
- Question: Looking at your system, do the Earth's structure and processes have a direct affect on human habitability? Does this make these factors less important?
- Answer: *The geological characteristics don't connect directly to the human body system. However, this does not make them less important than other factors. Without these processes and characteristics, Earth would be uninhabitable to humans. For example, if carbon dioxide was not regulated in Earth's atmosphere by the carbon cycle, we might have an increase or decrease in Earth's surface temperature, which could be harmful to human habitability.*





Geology Training Module	Temperature, Pressure, and the Earth	Density	Convection in the Earth	Plate Tectonics and Volcanism	Carbon Cycle and Life	Magnetic Field and Life	Geology Conclusion: Summarizing Learning
-------------------------	--------------------------------------	---------	-------------------------	-------------------------------	-----------------------	-------------------------	--

Sample Concept Map





Geology Training Module	Temperature, Pressure, and the Earth	Density	Convection in the Earth	Plate Tectonics and Volcanism	Carbon Cycle and Life	Magnetic Field and Life	Geology Conclusion: Summarizing Learning
-------------------------	--------------------------------------	---------	-------------------------	-------------------------------	-----------------------	-------------------------	--



Extend/Apply

(approximately 25 minutes)

1. Introduce the final project that will summarize student learning from this unit.

- Go over the Final Geology Project directions and rubric.

Note to Teacher: Some students may be interested in creating this guided tour on the computer using a slide show program such as "PowerPoint," "Hyperstudio," or "Kid Pix." This would be an excellent way for them to create images of the interior of the Earth and engage the class in a virtual tour of the Earth as a slide show or video.

- Draw students' attention to the Earth's geologic structure and processes that were the focus of this unit and their importance to human survival.
- You may want to brainstorm some of the advertising language and techniques that might be used to make the guided tour persuasive and inviting to tourists. These might stress the unique nature of a trip through the inside of the Earth or cost-saving hooks such as "two for the price of one."
- Allow students time to work on their final projects.

Note to Teacher: You may want to allow students to finish their guided tours as homework. Otherwise, you may need to allow more class time for completion.



Evaluate

(approximately 45 minutes)

1. Allow students to complete their guided tours.

2. Have students share their guided tours with a partner or group.

3. You may want to choose one or two guides from the class and take the class on an imaginary tour of the Earth's interior.

Note to Teacher: As you go through this tour and discussion, you may want to refer to the Earth's Structure Transparency included at the end of the lesson.

4. Discuss students' guides to ensure they have mastered the major concepts.

- Question: As tourists are travelling toward the center of the Earth, what kinds of changes would they notice?
- Answer: They would notice that pressure would increase, that the composition of the Earth would become denser, and that the core is hotter than the upper layers.*
- Question: If the tourists asked what causes these changes, what would you tell them?
- Answer: The pressure grows due to the weight of the overlying layers, which also causes internal heat to be generated. Denser materials sink below less dense material, causing layering.*





Geology Training Module	Temperature, Pressure, and the Earth	Density	Convection in the Earth	Plate Tectonics and Volcanism	Carbon Cycle and Life	Magnetic Field and Life	Geology Conclusion: Summarizing Learning
-------------------------	--------------------------------------	---------	-------------------------	-------------------------------	-----------------------	-------------------------	--

- Question: What would tourists notice about the states of matter inside the Earth?
- Answer: *They'd notice that the crust and upper mantle (lithosphere) is solid and brittle, that the lower part of the upper mantle (asthenosphere) was partially molten and the lower mantle is solid, but viscous, which allows it to flow rather than break. They'd also notice that the outer core is liquid and the inner core is solid.*
- Question: What would they notice about the relative size of the layers?
- Answer: *They'd notice that the lithosphere is very thin compared to the mantle and core.*
- Question: What processes would tourists observe and how are they important to human survival?
- Answer: *Tourists would see the process of how the movement of the liquid outer core around the inner core creates a magnetic field that helps protect humans from solar wind and space radiation. They would further see how plates move on the mantle, colliding and moving away from each other and that volcanoes occur at these plate boundaries. Finally, they would see how carbon is cycled in and out of the atmosphere by being trapped in limestone, subducted under a lithospheric plate, and then released through volcanoes. The carbon cycle regulates the amount of carbon dioxide in the atmosphere, which maintains a moderate surface temperature necessary for human survival.*

5. Collect students' Final Geology Projects and System Concept Maps, and evaluate them to ensure that they have each mastered the major concepts:

- The structure, composition, and mass of the Earth determines its structure and processes, all of which affect Earth's atmosphere and ability to support human survival.
- Like all systems, the Earth's structure is made up of parts that influence each other and can be part of other systems.
- The structure and composition of Earth's layers can affect the survival of humans.
- The amount of carbon dioxide in the atmosphere is an important factor in maintaining a moderate surface temperature.
- The amount of carbon dioxide in the atmosphere is determined by the carbon cycle, in which carbon is trapped in rocks and shells and then broken down and released through volcanoes.
- The slow movement of the crust and upper mantle results in volcanoes at plate boundaries. Movement in the mantle occurs as a result of convection. As mantle material increases in temperature, it becomes less dense and rises. When the temperature of the mantle material decreases, the density of the material increases and it sinks down.
- The lower part of Earth's upper mantle is partially molten. Earth's lithospheric plates float upon this layer.
- Earth's lower mantle is solid, but capable of flow due to the extreme pressures inside the Earth. The extreme pressure comes from the Earth's mass, which plays a role in making the inside of the Earth hot.
- The Earth's liquid outer core generates a magnetic field that, with the atmosphere, helps protect us from cosmic rays produced by exploding stars and harmful solar wind produced by our star, the Sun.

6. Bridge to next unit.

- Question: We've learned about the importance of the Earth's structure and processes for human habitability and we've learned about the importance of atmospheric gases and astronomical characteristics of our solar system for human habitability. If a planet has these astronomical, atmospheric, and geological characteristics, is it habitable to humans?
- Answer: *Not necessarily. There are still biological characteristics that the planet must also have.*
- Say: In the next unit we will learn about the biological characteristics that are necessary for human survival.

Note to Teacher: After each lesson, consider posting the main concept of the lesson some place in your classroom. As you move through the unit, you and the students can refer to the "conceptual flow" and reflect on the progression of the learning. This may be logistically difficult, but it is a powerful tool for building understanding.





Geology Training Module	Temperature, Pressure, and the Earth	Density	Convection in the Earth	Plate Tectonics and Volcanism	Carbon Cycle and Life	Magnetic Field and Life	Geology Conclusion: Summarizing Learning
-------------------------	--------------------------------------	---------	-------------------------	-------------------------------	-----------------------	-------------------------	--

System Concept Map

Draw a concept map that shows how the geologic structure and processes connect to the planetary temperature system and human body system to support human survival. Use different colors for the planetary temperature system, the human body system, the atmospheric gases, and geological characteristics/processes.

Include the following:

- All geologic processes and characteristics explored in this unit
- The planetary temperature system and its three primary components
- The human body system and important sub-systems
- The five atmospheric gases previously explored in the Atmosphere module: carbon dioxide, water vapor, oxygen, ozone, nitrogen
- An explanation of the connections you draw between the systems and the gases and why these connections are important to human survival

Your concept map will be evaluated using the following rubric:

4	<ul style="list-style-type: none">• The concept map clearly and accurately shows connections between all geological characteristics/processes, the planetary temperature system, and the atmospheric gases, forming one large concept map. The description clearly and accurately describes all connections and their relevance to human survival.• The concept map has all required parts, and the design elements (circles, color, and lines) are exceptionally clear and easy to understand.
3	<ul style="list-style-type: none">• The concept map clearly and accurately shows connections between all geological characteristics/processes, the planetary temperature system and the atmospheric gases, but may be in two separate concept maps. The description clearly and accurately describes the connections and their relevance to human survival.• The concept map has all required parts, and the design elements (circles, color, and lines) are clear and easy to understand.
2	<ul style="list-style-type: none">• The concept map is not completely clear or accurate in showing connections between some of the geological characteristics/processes, the planetary temperature system, and the atmospheric gases. The description is not completely clear or accurate in describing the connections and their relevance to human survival.• The concept map has most required parts, and the design elements (circles, color, and lines) are a little difficult to read.
1	<ul style="list-style-type: none">• The concept map is not clear or accurate in showing connections between geological characteristics/processes, the planetary temperature system, and the atmospheric gases. The description is not clear or accurate in describing the connections and their relevance to human survival.• The concept map is missing several parts, and the design elements (circles, color, and lines) are difficult to read.





Geology Training Module	Temperature, Pressure, and the Earth	Density	Convection in the Earth	Plate Tectonics and Volcanism	Carbon Cycle and Life	Magnetic Field and Life	Geology Conclusion: Summarizing Learning
-------------------------	--------------------------------------	---------	-------------------------	-------------------------------	-----------------------	-------------------------	--

Final Geology Project

Create a guided tour of the interior of the Earth that includes stops at:

- Crust
- Where two plates are colliding
- Where two plates are moving away from each other
- At a volcano
- At a formation of limestone
- Mantle
- Outer Core
- Inner Core

Include the following:

- Drawings and a description of the characteristics of each part of the Earth. Include composition, thickness, density, viscosity, pressure, and temperature in your descriptions. Include an explanation of the asthenosphere and lithosphere.
- Drawings and descriptions of the geological processes occurring inside and on the surface of the Earth. Include a description of movement in the mantle, plate tectonics, the generation of a magnetic field, and the carbon cycle.
- Explanations of how these characteristics and processes play a role in making Earth habitable to humans
- Use persuasive writing in your guide, as you are trying to sell people on the excitement of taking this tour through the Earth.

Your guided tour will be evaluated using the following rubric:

4	<ul style="list-style-type: none">• The guided tour clearly and accurately describes the structure and processes of the Earth and accurately describes the importance of these processes to human habitation.• The guided tour has all required parts, is creative, persuasive, and has accurate and clear illustrations that make the story exceptionally easy to understand.
3	<ul style="list-style-type: none">• The guided tour clearly and accurately describes the structure and processes of the Earth and accurately describes the importance of these processes to human habitation.• The guided tour has all required parts, and has accurate and clear illustrations that make the story easy to understand.
2	<ul style="list-style-type: none">• The guided tour is not completely clear or accurate in describing the structure and processes of the Earth or in accurately describing the importance of these processes to human habitation.• The guided tour has most required parts. Illustrations are a little difficult to read.
1	<ul style="list-style-type: none">• The guided tour is not clear or accurate in describing the structure and processes of the Earth and in accurately describing the importance of these processes to human habitation.• The guided tour is missing several parts. Illustrations are difficult to read.





Geology Training Module	Temperature, Pressure, and the Earth	Density	Convection in the Earth	Plate Tectonics and Volcanism	Carbon Cycle and Life	Magnetic Field and Life	Geology Conclusion: Summarizing Learning
-------------------------	--------------------------------------	---------	-------------------------	-------------------------------	-----------------------	-------------------------	--

Earth Structure Transparency

